PATENT SPECIFICATION 853,706

DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Valves for Controlling Re-Heat Fuel Supply Systems for an Aircraft Gas Turbine Engine.

We, JOSEPH LUCAS (INDUSTRIES) LIMITED, of Great King Street, in the City of Birmingham 19, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to means for controlling the supply of liquid fuel to a re-heat system for an aircraft gas turbine engine, said re-heat system comprising a plurality of individually operable burners.

The object of the invention is to provide a convenient and reliable arrangement of valves adapted so to operate that when an additional burner is brought into action, temporary impoverishment of the supply to a burner or burners already in action is obviated.

A valve arrangement in accordance with the invention comprises the combination of a plurality of main fuel control valves corresponding in number to the number of burners, each such valve being movable to its open position by fuel or other fluid pressure in a common supply pipe, an additional valve movable to its open position by fuel or other fluid pressure in association with each of the first mentioned valves excepting one, the additional valve serving to control the flow of liquid fuel from a branch supply pipe and being operable prior to the operation of its associated main valve for effecting preliminary filling of the associated burner supply pipe, and a plurality of independently operable control valves under the control of the pilot for controlling the fuel or fuel pressure operable valves.

The accompanying drawing illustrates diagrammatically a typical embodiment of the invention.

Referring to the drawing, the re-heat fuel is supplied by a pump to a common feed pipe a through automatic control means which are shown in the left hand portion of the drawing and will be described later. The pipe a is connected by a series of branches as a^1, a^2, a^3, a^4 to the valves forming the principal subject of the invention, and from these valves the fuel can flow through other branches as b^1, b^2, b^3, b^4 to the re-heat burners. The branch pipe a^1 leads to a valve box c^1. In this is contained a closure member d^1 which co-operates with a seating e^1 in communication with the outlet branch b^1. The closure member is secured to one end of a bellows f^1 and is loaded by a spring g^1 which (when the system is inactive) serves to hold the closure member in contact with its seating. In the closure member are formed passages as shown which include a restricted orifice h^1 through which fuel can flow through the bellows and a pipe i^1 through a restriction q^1 to a control valve box j^1. The latter contains a closure member k^1 which is normally held on a seating m^1 by a spring n^1 and is retractable from its seating by an electromagnet o^1 under the control of the pilot. When the closure member k^1 is moved off its seating, oil can flow from the valve box to a pipe p^1 leading to a sump.

The arrangement is such that when the

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pilot desires to bring the first re-heat burner into action he actuates a switch (as described later) for bringing the solenoid o^1 into action. The associated closure member k^1 is thereby moved away from its seating, and fuel can then flow from the interior of the bellows f^1 and through the pipes i^1, p^1, to the sump. The resulting drop of pressure within the bellows enables the pressure of the fuel in the branch a^1 to move the closure member d^1 away from its seating and so allow fuel to flow through the branch b^1 to the burner.

A similar valve to that above described serves to control the supply of fuel to the second re-heat burner. It comprises a valve box c^2, a closure member d^2, for controlling the flow to the branch b^2, a bellows f^2 and spring g^2. But before this valve is opened it is necessary to ensure that the pipe b^2 leading to the associated burner shall be filled with fuel, and thereby avoid risk of a temporary diminution of the flow already existing in the pipe b^1. To satisfy this requirement a second valve is provided in the valve box c^2. The second valve comprises a closure member d^x controlling a seating at the entrance to a passage b^x leading to b^2 and a bellows f^x loaded by a spring g^x. Fuel can enter the bellows through a restricted orifice h^x and can pass from the bellows through an orifice q^3 to a pipe i^2 leading to the valve box j^2. This latter contains a similar pilot-controlled valve to that contained in the valve box j^1. Fuel is supplied to the bellows f^x by a by-pass pipe a^x connected to main passage a, and can flow from the valve box j^2 to a sump through the above mentioned pipe p^1 which is common to all the valve boxes $j^1 \ldots j^4$.

Fuel can also flow from the bellows f^2 through an orifice q^2 situated adjacent to the orifice q^3, and the flow through these orifices is controlled by a lever r carrying a pair of closure members s which can close either of the said orifices. The lever extends through a seal to a compartment which is connected at t to the duct containing the re-heat burner and through which the hot propulsion gases are discharged. The said chamber also contains a bellows u which is loaded by an adjustable spring v, the lever r being connected to a stem y interconnecting the spring and bellows. The interior of the bellows is open to one end of a passage z which at its other end is connected to the end of the fuel pipe b^2 at a position adjacent to the burner supplied by this pipe.

The arrangement is such that when the valve in the valve box j^2 is closed, both of the closure members d^2 and d^x are in their closed positions. When the pilot opens the valve in j^2, fuel can flow from the pipe a^x, through the bellows f^x, orifice q^3, and passage i^2 to the valve box, and thence along p^1 to the sump. The effect of this is to cause the closure member d^x to be moved off its seating, so allowing fuel to flow along b^x to the branch b^2, and so cause the pipe leading to the associated burner to be filled. When filled, the fuel pressure in the pipe is transmitted along the passage z to the interior of the bellows u. The effect of this is to move the lever r in the direction for closing the orifice q^3 and opening the orifice q^2. Fuel can now flow from the bellows f^2, through q^2 to the valve box j^2, and thence to the sump, so causing the closure member d^2 to be moved off its seating, and allowing fuel to flow to the second re-heat burner from a^2 to b^2.

For controlling the supply of fuel successively to the other re-heat burners as b^3, b^4, there is provided for each a control means similar to that associated with the burner b^2, the said means being contained in valve boxes c^3, c^4, and controlled by electromagnetically operable valves j^3, j^4.

It will be evident that it is also desirable to be able to control the rate of supply of fuel to the valves above described from the supply pump, so that the fuel shall be supplied at an equal rate to all the re-heat burners when two or more are in action, and so that the rate shall also be variable with the speed of the blower which supplies the air for combustion of the fuel. For this purpose control means as shown in the left hand side of the drawing may be employed.

Referring to the first of these additional control means, there is connected to the fuel supply pipe a a valve box 2 containing a throttle 3 which is axially movable relatively to a throat 4. One end of the throttle is formed on or connected to a piston 5 in a cylinder 6. The other end is connected to a lever 7 through a tension spring 8. Also the lever is loaded by an additional and adjustable tension spring 9. The end of the cylinder remote from the throttle is open to the fuel pipe a by way of a restricted orifice 10. Also it communicates with a vent passage 11 which is controlled by a closure member 12 on one end of the lever 7. When the vent passage is closed, both sides of the piston are subject to the same fuel pressure. But when the said passage is open, a preponderating fuel pressure acts on the under side of the piston causing the latter to move upwardly for increasing the passage between the throttle and throat. Control of the lever 7 is effected by the action of blower air pressure on an elastic evacuated bellows 13 contained in a chamber 14, one end of the bellows being connected to the end of the lever remove from the vent passage by a rod 15 which passes through a seal 16. The arrangement is such that with increase of blower speed, and con-

sequent increase of blower air pressure, the lever 7 is moved in the direction for opening the vent passage 11, so causing the throttle to be moved in the direction for increasing the rate of flow of fuel past the throttle. In the example illustrated the action of the blower is also controllable by the pilot through a valve 17. This valve includes a closure member 18 which is loaded by a spring 19. Blower air is admitted at 20 through a restricted orifice 21 and can flow to atmosphere through a vent 22 at a rate determined by the position of the closure member. The said member is operable by a cam 23 on a spindle 24 which can be actuated by the pilot through a handle 25. Also there are mounted on the spindle 24 a series of cams 26, for actuating switches 27 arranged to control the circuits containing the solenoids in the valve boxes j^1, j^2, j^3, j^4. When all the valves in the said boxes are closed the closure member 18 occupies its fully open position. On bringing the first re-heat burner into action by actuation of the handle 25, the cam 23 will impart a small movement to the closure member 18 for diminishing the air flow to the vent 22 and so increasing the air pressure acting on the bellows 13, thereby causing the throttle 3 to be moved to a position in which adequate fuel can pass to the first re-heat burner. To bring the second burner into action a further movement is given to the handle 25, causing the second switch to close the circuit of the second solenoid, the first burner being maintained in action. The effect of this movement is to cause the closure member 18 to effect a further restriction of air flow to the vent and consequently cause a further increase of air pressure on the bellows 13, so causing a further increase of the throttle opening. A like action occurs when each of the other re-heat burners is brought into action, so as to ensure an adequate flow of fuel past the throttle 3 to supply fuel to all the burners equally.

Passing now to the other additional control means shown in the drawing, this serves to regulate the rate of fuel flow to the burners in response to the fuel pressure difference at the entrance and exit sides of the throttle 3 above described. This control means comprises a valve box 28 which is connected to the fuel pipe *a* as shown, and in which is contained a throttle 29 cooperating with a throat 30. The throttle is connected to a piston 31 contained in a cylinder 32, the piston being loaded at one side by a compression spring 33. The lower part of the cylinder containing the said spring is connected to the exit side of the throttle through a passage 34 containing a restricted orifice 35. The upper part of the cylinder communicates with the feed pipe *a* at the entrance side of the throttle 29. Also there is provided a vent 36 which is controlled by a closure member 37, the latter being carried by a flexible diaphragm 38 which separates two compartments 39, 40, and which is loaded by a compression spring 41 arranged to move the closure member to the position in which it closes the vent 36. The compartment 40 communicates with the entrance side of the throttle 29 by way of a passage 43. The compartment 39 communicates with the inlet side of the previously mentioned throttle 3 through a pipe 44. The diaphragm 38 is subject to the pressure difference between the inlet and outlet sides of the throttle 3. When this exceeds a given amount, the closure member 37 opens the vent 36, causing the piston 31 to move the throttle 29 in the direction for restricting the fuel flow past this throttle.

The joint action of the two control means above described is such that when only the first re-heat burner is in action the throttles 3 and 29 will take up positions such as will allow only the flow of the fuel required by this burner. When the second burner is brought into action both throttles will move in the direction for permitting an increased fuel flow. A similar action occurs when each of the other burners is brought into action.

The invention is not, however, restricted to the particular constructional details of the valves above described as minor details may be varied without departing from the essential features of the invention. Thus, for example, instead of electromagnets for controlling the valves in the parts j^1, j^2, j^3, j^4, any equivalent mechanical means may be employed, the cams 26 being then arranged to act directly on the closure members in the valve boxes j^1, j^2, j^3, j^4. Also whilst it is convenient to employ the pressure of the fuel for actuating the various fuel control valves, this is not essential, as any other pressure fluid may be used for this purpose, in which case the valves as d^1, d^2, etc. would be connected to corresponding fuel valves located in the fuel pipes.

WHAT WE CLAIM IS:—

1. Means for controlling the supply of fuel to a plurality of re-heat burners in a re-heat fuel supply system for an aircraft gas turbine engine, comprising the combination of a plurality of main fuel control valves corresponding in number to the number of burners, each such valve being movable to its open position by fuel or other fluid pressure in a common supply pipe, an additional valve movable to its open position by fuel or other fluid pressure in association with each of the first mentioned valves excepting one, the additional valve serving to control the flow of liquid fuel from a branch supply pipe and being oper-

able prior to the operation of its associated main valve for effecting preliminary filling of the associated burner supply pipe, and a plurality of independently operable control valves under the control of the pilot for controlling the fuel or fuel pressure operable valves.

2. In means as claimed in Claim 1, a first main valve comprising a closure member for controlling the flow of fuel from a common supply pipe to a pipe leading to the associated re-heat burner, a spring acting on the closure member, a bellows carrying the closure member and through which fuel from the said supply pipe can flow, the bellows being contained in a chamber in communication with the said pipe, and a pilot-controlled valve for controlling the fuel flow through the bellows, the arrangement being such that when the pilot-controlled valve is closed, the closure member is held on its seating by the spring, and when the pilot-controlled valve is opened, the fuel pressures acting on the bellows cause the latter to move the closure member to its open position.

3. Means as claimed in Claim 1 comprising a plurality of similar main fuel valves and actuating and control means therefore as claimed in Claim 2 for controlling the supply of fuel to a plurality of re-heat burners, and an additional control valve in combination with the second main control valve, or with each main control valve after the first, the said additional valve or valves being under the control of the said pilot-controlled valves, and means responsive to pressure of fuel in the pipe or pipes leading to the burners for effecting opening of the said main valve or valves after filling of the said pipe or pipes has been effected.

4. Means as claimed in Claim 1, having in combination therewith of a pair of throttles arranged in series for controlling the rate of supply of fuel to the main valves one of the throttles being adapted to be responsive to blower air pressure and the second being responsive to a fuel pressure difference associated with the first throttle, and means operable by the pilot for jointly controlling the blower air pressure and the control valves associated with the re-heat burners.

5. Means for controlling the supply of fuel to a plurality of re-heat burners in a re-heat fuel supply system for an aircraft gas turbine engine, comprising the combination and arrangement of parts substantially as described and as illustrated by the accompanying drawing.

MARKS & CLERK.

PROVISIONAL SPECIFICATION.

Valves for Controlling Re-Heat Fuel Supply Systems for an Aircraft Gas Turbine Engine.

We, JOSEPH LUCAS (INDUSTRIES) LIMITED, of Great King Street, in the City of Birmingham 19, a British Company, do hereby declare this invention to be described in the following statement:—

This invention relates to valves for controlling the supply of liquid fuel to a jet-propelled aircraft re-heat system which comprises a plurality of individually operable burners.

The object of the invention is to provide a convenient and reliable arrangement of valves adapted so to operate that when an additional burner is brought into action, temporary impoverishment of the supply to a burner or burners already in action is obviated.

A valve arrangement in accordance with the invention comprises the combination of a plurality of main fuel control valves corresponding in number to the number of burners, each such valve being movable to its open position by fuel or other fluid pressure in a common supply pipe, an additional valve movable to its open position by fuel or other fluid pressure in association with each of the first mentioned valves excepting one, the additional valve serving to control the flow of liquid fuel from a branch supply pipe and being operable prior to its associated main valve for effecting preliminary filling of the associated burner supply pipe, and a plurality of independently operable control valves under the control of the pilot for controlling the fuel operable valves.

In one example, in which the re-heat fuel is supplied by a pump to a common feed pipe, through any convenient automatic control means whereby the rate of supply to the said pipe is variable in accordance with the number of burners in action, there is provided a chambered body part having an inlet for connection to the feed pipe and an outlet for connection to a burner supply pipe. The entrance to the outlet is controlled by a closure member carried by an elastic bellows contained in the said body part. The interior of the bellows is connected through a restricted orifice to a control valve to be hereinafter described, and

the said closure member or bellows is provided with a restricted orifice through which fuel can continuously pass through the bellows to the control valve.

The control valve comprises a hollow body part having an inlet in communication with the interior of the bellows, and an outlet to a sump or other region of low pressure which is controlled by a spring-loaded closure member, the latter being movable to its open position by a solenoid under the control of the pilot.

The arrangement is such that when the associated burner is not in action the bellows-operated closure member is held on its seating by the bellows, and in this condition the pressure of the liquid fuel acts equally on the exterior and interior of the bellows. To bring the associated burner into action the pilot closes a switch for energising the solenoid. The effect of this is to open the control valve. The consequent outflow of fuel from the interior of the bellows reduces the pressure in the bellows, and the preponderating pressure then acting on the bellows causes it to move the closure member to its open position, thereby enabling fuel to pass to the burner.

A similar fuel-pressure operable valve is provided for controlling the supply of fuel to each of the other burners, but each such additional valve serves to control a flow of fuel to the associated burner from a branch pipe supplied by the pump, which fuel is required to fill the pipe leading to the burner before the associated main valve is brought into action. The second valve is similar to the main valve in that it comprises a closure member carried by an elastic bellows contained in a chamber having an inlet for connection to the branch pipe, and an outlet in communication with the outlet of the main valve. The chambers containing the bellows of the main valve and the additional valve are both in communication with a hollow body part containing a solenoid operable control valve similar to the one above described, through a valve carried by a lever which is operable in one direction by a spring for closing the communication between the main valve bellows and the pilot controlled valve, and is operable in the opposite direction by fuel pressure acting on the interior of a third bellows for closing the communication between the additional valve bellows and the pilot controlled valve, the spring and third bellows being contained in a third chamber.

It will be understood that when more than two re-heat burners are provided, a valve arrangement as above described is provided for each. The arrangement is such that when the associated burner is out of action both the main and the additional valves are closed, and only the bellows of the additional valve is in communication with the pilot controlled valve. To bring the second burner into action the pilot closes the appropriate switch and this enables the fuel pressure in the branch pipe to open the additional valve. The effect of this is to cause the pipe leading to the burner to be filled, so obviating any impoverishment of the supply to the first burner which is already in action. When the fuel pressure in the burner pipe reaches a predetermined amount the pressure exerted thereby on the third bellows causes the associated valve to be moved to its other position in which it closes the communication between the bellows of the additional valve and the pilot controlled valve, so causing the additional valve to close, and the main valve to open. The supply to the second burner is then maintained by the main valve.

Likewise when the pilot requires a third or more burners to become operative, he closes the appropriate switch or switches, and the first effect in each case is to cause the associated burner pipe to be filled before the main valve is opened.

Whilst it is convenient to arrange for the pilot controlled valves to be actuated by solenoids or other electromagnets, the invention is not restricted to this means, as these valves may be operable by any other convenient means such as cams operable by the pilot.

Further whilst it is convenient to employ the pressure of the fuel for actuating the various fuel control valves, this is not essential as any other pressure fluid may be used for that purpose, in which case the valve-actuating means would be isolated from the fuel passages.

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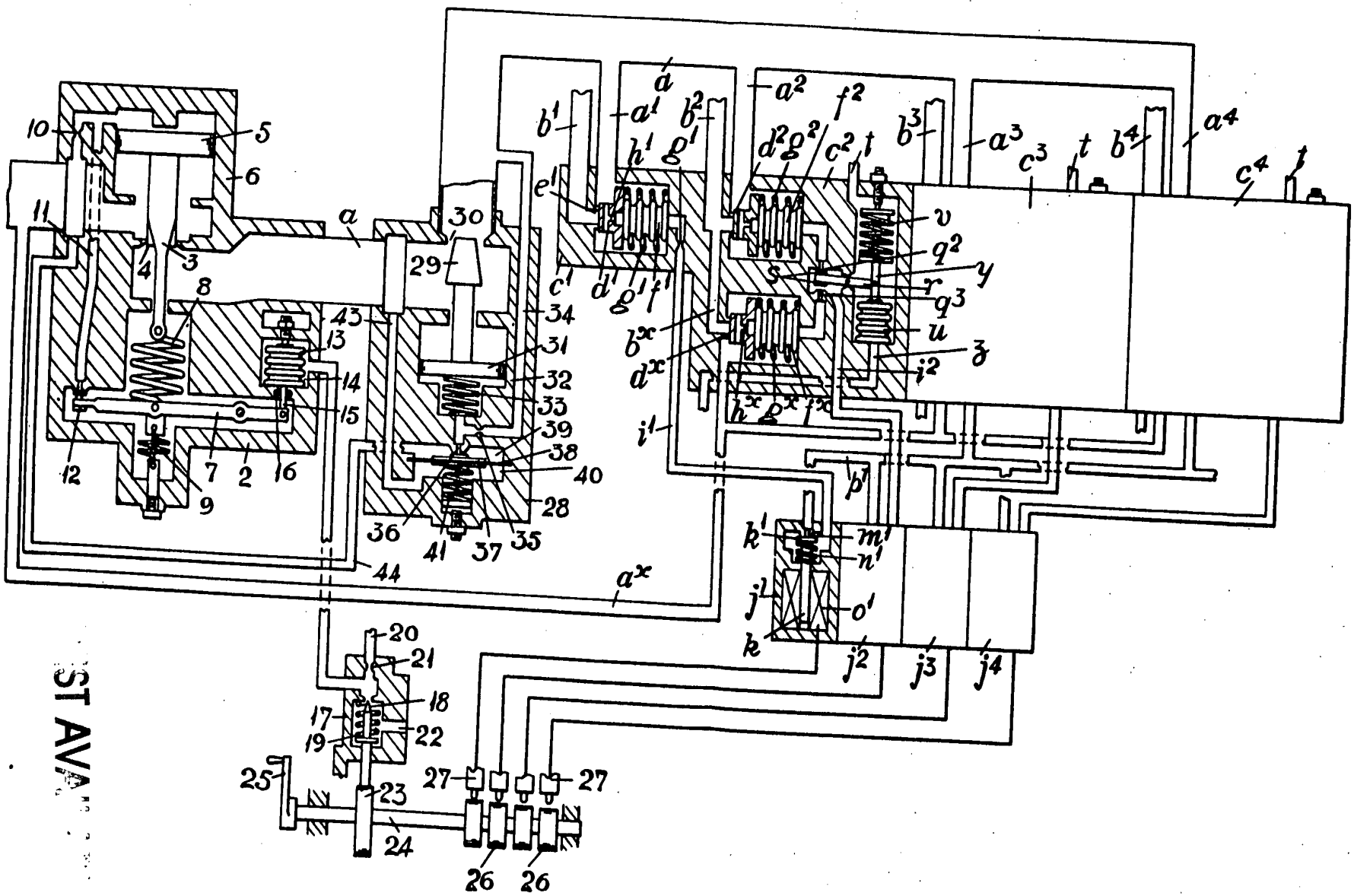
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